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The Galilean telescope has been used as an optical aid by low vision patients. The increase in size of the target caused by the magnification of the telescope allows the patient to then see the target. Normally sighted subjects were employed in this experiment. The Galilean telescope was used to determine its effect on the accuracy of these subjects while firing handguns. Comparisons between a group of average shooters and a group of more experienced shooters revealed a decrease in shot group size of the average shooters and an increase in the range or variability between group sizes of the more experienced shooters. Both were statistically significant at the $p<.05$ level. No statistically relevant data was recovered when both groups were analyzed together.

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The Effect of the Galilean Telescope on Handgun Shooting Accuracy

by

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Biographies

Raymond P. Herrera received his B.S. in Visual Science from Pacific University, Forest Grove, OR in 1991. He is a member of the American Board of Opticians.. He is a candidate for an O.D. degree at Pacific University College of Optometry in May of 1994. His future plans are to open a chain of optical super stores in the southwest.

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Dexel Peters received his B.S. in Visual Science from Pacific University, Forest Grove, OR in 1989. He is a candidate for an O.D. degree at Pacific University College of Optometry in May of1992. He has been a member of Beta Sigma Kappa and Phi Theta Epsilon during his college career. He will be serving with the U. S. Army in Korea after graduation. His future plans include private practice in Washington state or the southwest.

The Effect of the Galilean Telescope on Accuracy When Handgun Shooting

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Abstract

The Galilean telescope has been used as an optical aid by low vision patients. The increase in size of the target caused by the magnification of the telescope allows the patient to then see the target. Normally sighted subjects were employed in this experiment. The Galilean telescope was used to determine its effect on the accuracy of these subjects while firing handguns. Comparisons between a group of average shooters and a group of more experienced shooters revealed a decrease in shot group size of the average shooters and an increase in the range or variability between group sizes of the more experienced shooters. Both were statistically significant at the $p \leq .05$ level. No statistically relevant data was recovered when both groups were analyzed together.

Introduction

The Galilean telescope[1] is typically used as a low vision aid for those patients needing small amounts of magnification. The magnification of the telescope causes an increase in apparent target size as would moving the target closer to the subject but without the proximal effect on convergence and accommodation. Since the telescope causes an increase in apparent size, a distant target viewed through the telescope would appear to be of the same size as a nearer target viewed without the use of the telescope when the magnification factor of the device is equal to the distance magnification caused by the nearer target position.

The accuracy of shot groups fired by marksmen at close range targets are typically smaller then those that are shot with the target at longer ranges. There are factors other than target size involved in that difference. They include bullet drop caused by the effect of gravity on the bullet during it's flight between the firearm and the target, the effect of wind on bullet trajectory and those small errors in sighting, trigger control or weapon stability which are magnified as the distance to the target is increased. When the target's apparent size remains constant, will a significant increase in accuracy result when the other factors remain the same? If a substantial increase in accuracy is achieved the Galilean telescope may be useful as an alternative to the long eye relief pistol scope which usually has comparable magnification but a smaller field of view. Target shooters could benefit from the magnification of the target. Advantages to hunters would be a larger field of view compared to long eye relief pistol scopes which would make sighting moving game easier. They would also profit from the magnification factor.

Methods and Materials

Thirteen normally sighted marksmen were the subjects were the subjects for this research. Myopes, hyperopes and emmetropes were

represented in the subject population. All but one of the subjects was able to achieve a clear, magnified target picture without his correction. The other subject wore the telescope over his spectacles . This presented no problem in the use of the telescope for him and he too achieved a clear magnified view. These marksmen shot a total of eight, five shot groups at separate targets. Four groups were shot while employing the nominally 3x Galilean telescope and four groups while using their habitual correction. Subjects were divided at random into two groups, one group to fire first with the telescope in place and the other group without the telescope initially. This was done to reduce any possible practice effect that may have been present. Four of the thirteen participants were judged to be more experienced and proficient marksmen than the other participants. This was based on their habitual correction group sizes and on their more extensive handgun shooting experience.

The shooting was done at an indoor range so no wind effects on the bullet were present. Groups were shot at seven yards, a standard near target distance. This distance reduced the time that the bullet was in flight and under the effect of gravity therefore reducing bullet drop. The targets that were used were standard 50 ft. NRA pistol targets. The subjects were allowed to fire the handgun and ammunition of their choice. Firearms that were used were .22 revolver and semi-auto, .38 Special revolver, 9mm Parabellum semi-auto and .45 ACP semi-auto. The firing was not timed and the subjects were allowed to fire at their own rate. Subjects were instructed to adjust the telescope to produce the largest and clearest target picture that was possible. They were then instructed to fire as they normally would, standing with a one or two handed hold with no other support

A 3x spectacle type Galilean telescope was used as the device to increase the target size. The telescope consisted of two pair of lenses, one in front of the other, in a spectacle mounting. A wheel on each side of the telescope allowed for adjustment of the distance between the lenses in order to focus the device for a specific target distance. No effort was made to achieve a clear front sight picture. A blinder for one lens was not used during the shooting with the

telescope or without it so the subjects were able to use both eyes during the shooting if they desired.

Shot groups were measured from center to center of the bullet holes that were the greatest distance apart on each target. The measurements were made to the nearest sixteenth of an inch. Obvious fliers, a widely errant shot in an otherwise tight group, were thrown out. Each subject's groups were also measured for range, that difference between the smallest and largest group size, in order to establish the individual's consistency from target to target. The mean group size and range were analyzed using a two-tailed t-test with $p \leq .05$ as the significance level. This analysis was performed for three different groups; experienced shooters, average shooters and all shooters combined.

Results

The mean group size and range of each individual subject, both with and without the telescope in use, were analyzed with a double tailed T-test to determine if a statistical decrease in group size, hence an increase in accuracy, or decrease in range, hence an increase in consistency, occurred while firing with the telescope as opposed to without it's use. Significant results at the $p \leq .05$ level were only realized in two areas. The first was in the comparison of the mean group size of the average shooters. There was a .611 inch (18.4%) reduction in mean group size for the average shooters when they shot with the telescope with probability of .0045. The other area was the range of the more experienced shooters. Their mean range increased by .78 inches (83.0%) when using the telescope with probability of .0229. The mean group size of the more experienced shooters showed an increase in size also but only at $p = .0752$ which did not quite put it into the $p \leq .05$ level. When all shooters were analyzed together no statistically significant data was recovered.

A questionnaire was given to each of the participants to fill out concerning their qualitative assessment of the ability of the telescope to aid them in their shooting. The complaint that every shooter made was that the front sight blade was not clear enough. Eleven of

the shooters, including all of the shooters in the experienced group considered the telescope of no aid to their shooting. Only two of the thirteen subjects, both in the average shooters group, thought that the device may be of any aid to them in shooting. These two commented that the magnification was a help to them in holding the firearm steadier on the target. One of these mentioned that while he thought that the device was of help to him shooting he felt that it made it harder to handle his weapon and reload it.

Mean and Range Analysis : Experienced Shooters

Paired t-Test X1: SNmn Y1: STmn

DF	Mean X-Y	Paired t value	Prob.(2-tail)
3	-0.873	-2.678	0.0752

Differance between group size with and without telescope
SNmn = mean group size with habitual correction
STmn = mean group size with telescope

Paired t-test X2: SNrng Y2: STrng

DF	Mean X-Y	Paired t value	Prob.(2-tail)
3	-0.78	-4.317	0.0229

Differance between range with and without telescope
SNrng = range with habitual correction
STrng = range with telescope

Mean and Range Analysis: Average Shooters

Paired t-test X1: SNmn Y1: STmn

DF	Mean X-Y	Paired t value	Prob.(2-tail)
8	0.611	3.902	0.0045

Differance between mean group size with and without telescope
SNmn = mean group size with habitual correction
STmn = mean group size with telescope

Paired t-test X2: SNrng Y2: Strng

DF	Mean X-Y	Paired t value	Prob.(2-tail)
8	-0.151	-0.377	0.7161

Differance between range with and without telescope
SNrng = range with habitual correction
STrng = range with telescope

Mean and Range Analysis: All Shooters

Paired t-test X1: SNmn Y1: STmn

DF	Mean X-Y	Paired t value	Prob.(2-tail)
12	0.155	0.639	0.5349

Differance between mean group size with and without telescope
SNmn = mean group size with habitual correction
STmn = mean group size with telescope

Paired t-test X2: SNrng Y2: Strng

DF	Mean X-Y	Paired t value	Prob.(2-tail)
12	-0.345	-1.191	0.2568

Differance between range with and without telescope
SNrng = range with habitual correction
STrng = range with telescope

Descriptive Stats, experienced shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
1.502	0.69	1.88	0.547	Habitual Rx
2.375	1.19	3.56	1.001	Telescope

Group size data of experienced shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
0.94	0.13	1.63	0.618	Habitual Rx
1.72	1.06	2.69	0.754	Telescope

Range data of experience shooters

Descriptive stats, average shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
3.6	2.44	6.63	1.239	Habitual Rx
2.989	1.19	6.19	1.435	Telescope

Group size data of average shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
1.496	0.38	3.56	0.927	Habitual Rx
1.647	0.56	3.31	0.932	Telescope

Range data of average shooters

Descriptive stats, all shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
2.955	0.69	6.63	1.454	Habitual Rx
2.8	1.19	6.19	1.308	Telescope

Group size data of all shooters

Mean	Minimum	Maximum	Std. Dev.	Condition
1.325	0.13	3.56	0.86	Habitual Rx
1.669	0.56	3.31	0.85	Telescope

Range data of all shooters

Questionnaire

1. Did you like the magnification system? Y N

2. If no, what didn't you like about it?

3. If yes, can you think of any other applications for this system? (hunting, archery, etc)

4. How could you improve this system?

5. Would you purchase this type of magnification system?

Discussion

A statistically significant decrease in shot group size was hoped for as a result of this research. This decrease (18.4%) was achieved by the group of average shooters. This was not the case with the experienced shooters or when the two groups were analyzed together. Only the experienced group of shooters revealed any statistically significant results in the range of the groups. This however was a counter productive result. The range of the experienced shooters increased, divulging an decrease in consistency of the different shot group sizes. While there was a statistically significant decrease in the groups of the average shooters it may not be a decrease of practical significance when taking into account the amount the front was blurred and the necessity of wearing the device. All of the subjects complained that the front sight was very blurry. This was a problem we had foreseen but we did not think it would be of such magnitude. Since the front sight is approximately one meter in front of the shooter one diopter of accommodation would be needed to see it clearly. This is not possible while using the telescope. We had thought that the one diopter blur of a target as large as a front sight blade would perhaps be tolerable. That assumption was wrong. Most experienced shooters agree that a good front sight picture is essential to accurate shooting. The rear sight is not of such importance and is usually blurred as the shooter is concentrating on the front sight and the target. We believe that this blur of the front sight was the major contributing factor in the great increase (83.0%) in range shown by the experienced shooters group. When the front sight is blurred or invisible as it maybe in a low light situation the marksman must rely on his natural pointing ability. This doesn't provide as great amount of accuracy or consistency as deliberate shooting using the front sight does for most experienced shooters. We believe that the reason that the average shooters showed an increase in accuracy while using the telescope is because they use that natural pointing ability more then the experienced

shooters and are not so careful about a precise front sight alignment on the target. The magnification provides a larger target to point at.

Drawing any concrete conclusions from this data may be somewhat premature since the sample population for this study was quite small especially when the data from only the experienced shooters was analyzed.

The Galilean telescope in it's present form does not appear to be of a great benefit to target shooters. No obvious benefit to hunters seems to be present either. If a way can be found to clear the front sight and still enjoy the magnification to the target a benefit might be realized from the device. Perhaps a small aperture occluder over the lenses or using the telescope over one eye and the shooter's habitual correction over the other eye. This maybe an option if the shooter can superimpose both images. If one of these situations would yield acceptable results both target shooters and hunters could possibly benefit.

References

1. Mehr EB, Freid AN. Low Vision Care. New York: Professional Press: 1985: 67,74.